Technology Focus: Test & Measurement

Wireless Measurement of Contact and Motion Between Contact Surfaces

A magnetic-field-response contact sensor is used.

Langley Research Center, Hampton, Virginia

This method uses a magnetic-field- response contact sensor that is designed to identify surface contact and motion between contact locations. The sensor has three components: (1) a capacitor-inductor circuit with two sets of electrical contact pads, (2) a capacitor with a set of electrical contact pads, and (3) an inductor with a set of electrical contact pads. A unique feature of this sensor is that it is inherently multifunctional. Information can be derived from analyzing such sensor response attributes as amplitude, frequency, and bandwidth. A change in one attribute can be due to a change in a physical property of a system. A change in another attribute can be due to another physical property, which has no relationship to the first one.

The sensor is powered and interrogated without physical connection to a power source, microprocessor, data acquisition equipment, or electrical circuitry. It works with the magnetic-field-response recorder described in "Magnetic-Field-Response Measurement-Acquisition System," *NASA Tech Briefs*, Vol. 30, No. 6 (June 2006), page 28.

The sensor (capacitor-inductor circuit) is placed on the moving object as shown in the figure. When contact is made between stationary surface A, the capacitor and the capacitor-inductor circuit form a circuit the response frequency of which is

$$\omega = \frac{1}{2\pi\sqrt{2LC}}$$

The contact pads could be compressible or spring-loaded electrical contacts that are electrically connected to the sensor. Movement away from surface A to the next surface results in the sensor response frequency shifting to

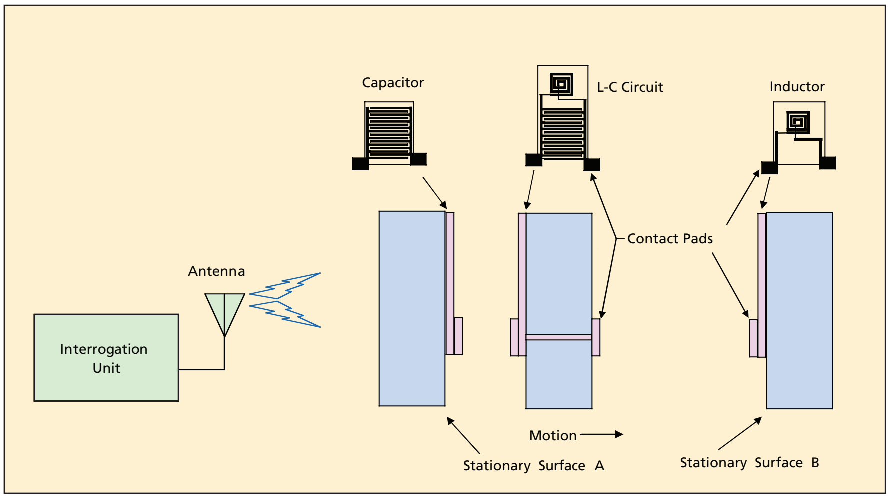
$$\omega = \frac{1}{2\pi\sqrt{LC}}$$

The response amplitude decreases as the sensor moves away from the antenna. Contact with surface B shifts the sensor response frequency to

$$\omega = \frac{1}{2\pi}\sqrt{\frac{2}{LC}}$$

Applications for this include being able to tell whether doors or hatches are sealed, surface bonds are secure (tile bonds, rubber bond to steal belts of tires, etc.), general knowledge of contact between two surfaces, or separation of surfaces.

This work was done by Stanley E. Woodard of Langley Research Center and Bryant D. Taylor of Swales Aerospace. Further information is contained in a TSP (see page 1). LAR-16849-1



Edge View of Object is shown moving away from surface A toward surface B. Surface A has a capacitor with electrical contact pads. Surface B has an inductor with contact pads. The moving object has a inductor-capacitor circuit with two sets of contacts pads to complete the electrical connection with either surface.

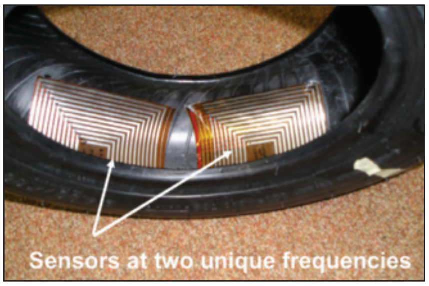
Wireless Measurement of Rotation and Displacement Rate

A magnetic field response sensor is used in these measurements.

Langley Research Center, Hampton, Virginia

A magnetic field response sensor is designed to measure displacement or rotation rate without a physical connection to a power source, microprocessor, data acquisition equipment, or electrical circuitry. The sensor works with the magnetic field response recorder, which was described in "Magnetic-Field-Response Measurement-Acquisition System," *NASA Tech Briefs*, Vol. 30, No. 6 (June 2006), page 28. These sensors are wirelessly powered and interrogated, and the measurement acquisition system and sensors are extremely lightweight.

The response recorder uses oscillating magnetic fields to power the sensors. Once powered, the sensors respond with



Two Response Sensors with different resonant frequencies are sown inside of wheel.

their own magnetic field. For displacement/rotation measurements, the response recorder uses the sensor's response amplitude, which is dependent on the distance from the antenna. The recorder's antenna orientation and position are kept fixed, and the sampling period is constant.

A sensor with fixed frequency and fixed orientation with respect to the response recorder antenna can be used for position and displacement measurements. If the sensor's orientation is not fixed, but its trajectory is known, it may be possible to calibrate the response amplitude variation with trajectory. For rotational motion such as wheel speed, identifying the number of times the response amplitude exceeds threshold amplitude in a fixed time duration can be used to determine rotation rate. A wheel speed sensor is shown in the figure. The sensor is a thin-film circuit placed inside the wall of a tire. As the sensor approaches the antenna, the amplitude increases. The amplitude peaks at the closest point to the antenna then decreases producing changes in amplitude that are cyclical. When two sensors with different respond frequencies are used inside the wheel, rotation direction can be determined by identifying which sensor's amplitude increases first. In addition, there is no mechanical wear because no gears are used in the design.

This work was done by Stanley E. Woodard of Langley Research Center and Bryant D. Taylor of Swales Aerospace. Further information is contained in a TSP (see page 1). LAR-16848-1

Portable Microleak-Detection System

Heating or cooling of a vacuum seal enables testing over a wide temperature range.

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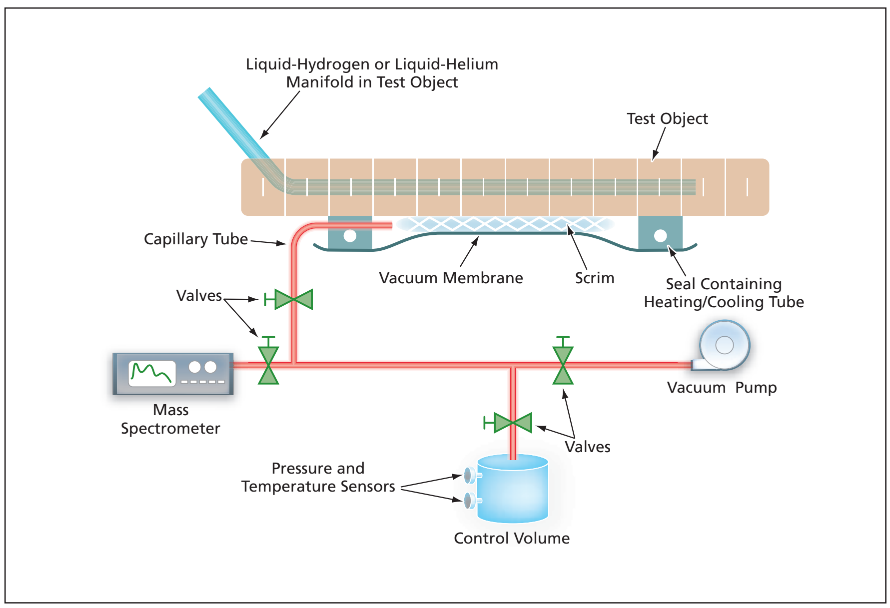
The figure schematically depicts a portable microleak-detection system that has been built especially for use in testing hydrogen tanks made of polymer-matrix composite materials. (As used here, "microleak" signifies a leak that is too small to be detectable by the simple soap-bubble technique.) The system can also be used to test for microleaks in tanks that are made of other materials and that contain gases other than hydrogen. Results of calibration tests have shown that measurement errors are less than 10 percent for leak rates ranging from 0.3 to 200 cm^3/min.

Like some other microleak-detection systems, this system includes a vacuum pump and associated plumbing for sampling the leaking gas, and a mass spectrometer for analyzing the molecular constituents of the gas. The system includes a flexible vacuum chamber that can be attached to the outer surface of a tank or other object of interest that is to be tested for leakage (hereafter denoted, simply, the test object). The gas used in a test can be the gas or vapor (e.g., hydrogen in the original application) to be contained by the test object. Alternatively, following common practice in leak testing, helium can be used as a test gas. In either case, the mass spectrometer can be used to verify that the gas measured by the system is the test gas rather than a different gas and, hence, that the leak is indeed from the test object.



The **Portable Microleak-Detection System** includes components in common with prior microleak-detection systems, plus a seal-heating/cooling subsystem that enables testing over a wide temperature range.

The flexibility of the chamber makes it adaptable to test objects having a variety of simple or complex shapes. The flexible vacuum chamber includes an aluminized polyethylene terephthalate vacuum membrane that is sealed to the outer surface of the test object by a flexible, adhesive seal material. A scrim is placed between the inner surface of the membrane and the outer surface of the test object to maintain a gap to accommodate the flow of any leaking gas. A capillary tube that passes through the seal connects the gap volume with the plumbing that leads to the mass spectrometer, the vacuum pump, and a control volume described next.

The control volume has a known size and is instrumented with pressure and temperature sensors. In use, the control volume is evacuated, then disconnected from the vacuum pump, and then the pressure and temperature are measured as the leaking gas flows into the control volume. By use of the ideal-gas law, the rate of leakage can be calculated from